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1.	Your reference	P2021-GB
2.	Patent application number	14 SEP 1999 **9921520.4** 14 SEP 1999
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	Mr Frederick Pearson 7 Victoria House Weston Road Bath BA1 2XY
	Patents ADP number *(if you know it)*	7738158001
	If the applicant is a corporate body, give the country/state of its incorporation	
4.	Title of the invention	Treatment of Carbonaceous Material
5.	Name of your agent *(if you have one)*	K R Bryer & Co 7 Gay Street Bath BA1 2PH
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	
	Patents ADP number *(if you know it)*	10777002

6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing *(day / month / year)*

8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	NO

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Abstract	0
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Priority documents	0
Translation of priority documents	0
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	0
Request for preliminary examination and search *(Patents Form 9/77)*	1 ✓ R
Request for substantive examination *(Patents Form 10/77)*	0
Any other documents *(please specify)*	0

11. I/We request the grant of a patent on the basis of this application.

Signature: K. R. Bryer & Co

Date: 13/9/99

12. Name and daytime telephone number of person to contact in the United Kingdom: (01225) 428877 Paula John

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TREATMENT OF CARBONACEOUS MATERIAL

The present invention is generally directed towards improvements in the treatment of carbonaceous material. The present invention is concerned with a process, and apparatus therefor, for the treatment of carbonaceous material, including organic matter, and is particularly, although not exclusively, directed to the disposal of human or animal remains.

The disposal of carbonaceous material has conventionally been conducted by combustion in purpose-built furnaces. Such incineration has, until recently, been the method of choice for the disposal of a wide variety of carbonaceous matter including plant materials, synthetic materials such as motor vehicle tyres, medical waste, as well as human or animal remains.

Although originally thought to offer an efficient and relatively clean process, the consequences of incineration of carbon based materials have become increasingly apparent. It is now evident that significant and harmful emissions of toxic compounds occur during incineration and that the compounds released include potent polychlorinated carcinogens such as dioxins and the related dibenzofurans. A number of studies have linked levels of such compounds, which persist in the environment and steadily accumulate in the food chain, to increased incidences of a wide range of cancers including lung and testicular cancers.

Hospital incinerators, household waste incinerators and crematoria, have all been identified as significant contributors to such pollution and, as a result of recent

legislation and the threat of future legislation, are increasingly under pressure to control their emissions.

The degradation of carbonaceous material including organic matter, has therefore become a subject of much investigation with some recent developments focusing on ways of achieving thermal degradation (pyrolysis) of the material without incineration. Several such methods are known to involve the absorption of electro-magnetic energy in the form of microwave, infra-red and radio-frequency radiation so as to cause pyrolysis. Briefly stated, the absorption of energy into the organic material by microwave irradiation for example, causes the fission of the molecular bonds comprising the material in a process resembling the absorption of thermal energy. The process, which is conducted in an oxygen deficient environment to prevent possible spontaneous combustion, does not therefore lead to the high temperatures caused by a combustion process nor to the products of uncontrolled recombination of the constituent atoms of the material with oxygen. Put another way, chemical reactions resulting from degradation of the material occur in a "reducing" environment rather than the "oxidising" environment of combustion. Consequently the formation of compounds of the toxic nature of the oxygen-containing dioxins and furans is largely avoided and other harmful emissions are also significantly reduced.

The use of microwave irradiation for degradative pyrolysis of organic matter has hitherto been directed to the reduction of tyres, household or medical waste and the like. One such process, the so called Emery Process, first described for the

reduction of tyres and medical waste, has been adapted for commercial use as a medical or biomedical waste reduction system. The method, commercially known as "reverse polymerisation", comprises the use of a housing arrangement in which there are located a number of chambers for the treatment of the waste material. A continuous feed introduces the waste material into a first compartment whilst the atmosphere within the housing is purged of oxygen. The material is then fed into a second chamber where it is irradiated with microwave radiation generated by an array of transducers. After irradiation the degraded material is fed into a third compartment where it is allowed to cool and is then collected as a sterile ash-like carbon residue. The gaseous by-products of the fission of the material, which are mostly water in the form of steam and carbon dioxide are also collected by means of trapping either by condensation or by reaction with sodium hydroxide solution. The residue of the process is generally not further treated and is disposed of in land-fill.

The prior art also includes WO 89/04355 A1 which discloses a similar method for the treatment of carbonaceous matter (Holland Process) describing the preliminary step of heating tyre waste to a temperature of at least 250°C before microwave irradiation. The heating means is substantially effected by recycling of the gaseous products of the previous degradation from the microwave irradiation zone within a housing to a preheating zone within the same housing.

The present invention originates from the viewpoint that under certain circumstances the treatment of carbonaceous material by microwave irradiation,

with or without preliminary heating, may not proceed to an acceptable level of completion.

According to the present invention therefore, there is provided a process for the treatment of carbonaceous material comprising the steps of i) introducing the material, into a chamber having closure means, ii) extracting or displacing oxygen from the chamber so as to provide a substantially oxygen-depleted atmosphere, iii) effecting a preliminary treatment of the material by irradiating with electro-magnetic radiation of sufficient power and for a sufficient period to cause substantial degradation of the carbonaceous material to an ash-like residue, and iv) raising the temperature of the thus-obtained residue in the presence of oxygen or air whereby to cause combustion and reduce the said residue to an ash.

The present invention thus not only provides for a further reduction in volume of the processed material compared to microwave irradiation alone, but also allows for the possibility of varying the extent of irradiation so that susceptible matter is degraded and less susceptible matter is incinerated. Thus disposal may be optimised and extraneous matter may be tolerated. One circumstance in which such considerations may arise is in the treatment of human or animal remains.

It will be understood that neither of the prior art processes discussed above could be directed toward the treatment of human or animal remains without significant adaptation to fulfil strict legal conditions that such remains must be disposed of by a process involving combustion.

In one embodiment of the invention step iv) is performed by combustion of at least one combustible gas. In another embodiment step iv) comprises introducing air or oxygen and the combustible gas into the said chamber. Alternatively step iv) may be performed by removing the residue obtained by step ii) from the said chamber to a second chamber, equipped with means for introducing air or oxygen and containing heating means which may include introduction and combustion of combustible gas.

The ignition of the combustible gas may be achieved by any known means, for example it may be initiated by further irradiation with electromagnetic radiation.

In preferred embodiments of the invention step iii) is performed by irradiating the material with microwave radiation. Preferably the process includes the further step of weighing the material to be treated so as to determine the energy level and/or time for which irradiation should be continued in order to achieve the desired result. Preferably the weighing step occurs before step iii). Alternatively the weighing step may occur during step iii) so as continuously to relate the material remaining with the energy level and/or time of irradiation required to achieve the desired level of degradation.

The process of the present invention may also include the further step of cooling the solid products of step iv) before collection. In another embodiment of the invention the process may further include the step of trapping the gaseous products

of step iii) and/or step iv). The trapping means may involve chemical or physical transformation of the effluent gases.

In a preferred embodiment of the present invention, for example in the treatment of a coffin and body, the process may also comprise a further step whereby the carbonaceous material is pre-heated prior to the irradiation. The pre-heating step serves to prevent the development of a pressure gradient during the initial stages of the irradiation, in particular allowing means by which the coffin seal may be broken.

It will be understood that the process of the present invention leads to a white ash of substantially reduced volume than the black residue obtained by processes involving irradiation without combustion.

The present invention also provides for apparatus for the treatment of carbonaceous material comprising a housing defining at least one chamber and having an opening for introducing the material into the said at least one chamber together with closure means for closing the said at least one chamber, said housing also comprising means for extracting or displacing oxygen from the said at least one chamber so as to provide a substantially oxygen-depleted atmosphere in the said at least one chamber, means for irradiating the material in said at least one chamber with electromagnetic radiation of sufficient power and for a sufficient time as to cause degradation of the said material to an ash-like residue, means for admitting air, or oxygen into the presence of the residue, and means for raising the

temperature of the said residue within the said at least one chamber so as to cause substantial combustion thereof to lead to an ash.

In one embodiment of the invention the apparatus further comprises means for introducing at least one combustible gas into the at least one chamber and means for ignition of the combustible gas.

In another embodiment of the invention the apparatus includes means for weighing the carbonaceous material prior to, or upon introduction of the material into the chamber.

In presently preferred embodiments of the invention the apparatus further comprises cooling means for cooling the solid products of combustion and may also comprise collecting means for collection of the solid products.

In one embodiment of the invention the apparatus also provides for the collection of the gaseous products of irradiation and/or combustion. The collection means may be condensers for the collection of water and sodium hydroxide or neutramag (trade name) or other means for the trapping of carbon dioxide.

In another embodiment of the invention the apparatus may comprise means for generating nitrogen or oxygen-depleted air. Alternatively the apparatus may include merely a store of nitrogen or oxygen-depleted air.

In a presently preferred embodiment of the invention the apparatus includes heating means for pre-heating the carbonaceous material prior to irradiation. The pre-heating means may also comprise means for effecting combustion of the material after irradiation. In a particularly preferred embodiment the heating means comprise infra-red hotplates.

In another embodiment of the present invention at least one chamber is formed in a portable housing having the housing has means for connection to an external energy source. The apparatus may also be of a modular nature allowing housings to be stacked upon each other or otherwise closely arranged. In this embodiment the housings will each contain means for irradiation and combustion of the material therein introduced but may share sources of energy, and sources of inert gas as well as trapping means for the collection of gaseous products of irradiation and combustion. Preferably, however each housing will have separate collecting means for collecting the solid products of combustion.

Various embodiments of the process and apparatus of the present invention will now be described by way of non-limiting example with reference to the following drawings in which

Fig. 1 is an isometric cut-away view of a first embodiment of the invention;

Fig. 2 is a schematic diagram illustrating apparatus for performing the process of the present invention;

Fig. 3 is an isometric cut-away view of a third embodiment of the present invention;

Fig. 4 is an isometric cut-away view illustrating the modularity of the apparatus of the present invention.

Referring now to the drawings and particularly to Fig. 1, apparatus for performing the process of the invention comprises a portable housing 11 having a single chamber 12 for receipt of a coffin 13 containing a human body. The coffin 13 is introduced into the chamber via an opening 14 onto a gangway 15 formed on or in the chamber floor 16. The opening 14 is fitted with a lockable door (not shown) so as to form an air tight seal on closure. Chamber floor 16 is formed as a plate or tray with slide engagement means for sliding in and out of the housing 11. A perpendicular wall 17 formed at a single edge of the plate fits into an aperture defined in the side panelling of the housing and has there handles 18 so as to allow withdrawal of the chamber floor 16 at the end of the treatment process. Housing 11 further includes a compartment 19 arranged underneath chamber 12. Compartment 19 contains essential electrical, mechanical, computing and monitoring equipment necessary for the operation and monitoring of the treatment process. Control dials 20 are arranged in the side wall of compartment 19 for control and adjustment of the treatment process. For example, in the embodiment illustrated the compartment 19 has ignition means 21 projecting through apertures 22 in chamber floor 16. The ignition means 21 comprises spark plugs and apertures 22 serve for the introduction of a combustible gas or mixture of gases into chamber 12.

In an alternative embodiment of the invention (not shown) the compartment 19 takes the form of a drawer in the side of the housing 11 so that it may be withdrawn from the housing for access to the operating machinery. The compartment may also house a cremulator (not shown) for grinding of the ash obtained at the end of the process should it be required. In one such embodiment chamber floor 16 is not withdrawn from the housing at the end of the process but provided with a chute or similar so as allow the ash to be transferred to the cremulator.

Housing 11 further includes a roof panel 23 which can slide in and out of a channel defined in the side wall panels. Roof panel 23 includes an array of transducers 24 for irradiating the chamber with microwave radiation arranged in a honeycomb panel behind a microwave transparent glass screen (not shown). The transducers 24 are electrically connected to a transformer or generator in compartment 19 or an external power supply by connecting wires extending through the side panelling of the housing 11. Transducers 24, which may comprise magnetrons and have water cooling means, are protected from the effects of irradiation and combustion by the glass screen, which is constructed to withstand temperatures of up to 1500°C.

The front wall of the housing, in which is located the opening 14 together with its associated door, has a control panel 25 for selecting the time and/or energy level of the treatment process by the operator. This selection may be made by reference to monitoring equipment or according to the experience of the operator. To aid in the

selection of the desired time for irradiation, a spy hole 26 is provided adjacent the door so that the extent of degradation can be determined visually. Spy holes 26 may of course be provided at any convenient position in the housing 11 including within the roof panel 23 and may take the form of video cameras. Roof panel 23 further provides means for the introduction of inert gas or nitrogen gas or oxygen-depleted air into the chamber as well as exit means for the evacuation of air, purging or effluent gases. It will be appreciated that where such means are provided, as in the case of the door for opening 14 and chamber floor 16, hermetic sealing means must also be provided.

The embodiment illustrated in Fig. 2 includes means for generating nitrogen from atmospheric air. The generated nitrogen is introduced into the chamber 11 through aperture 27 via a conduit or other pipeline. The introduction of nitrogen into the chamber purges the chamber of air by displacement. The purging gas and atmospheric gas exit the housing through apertures 28 or 29 in roof 23 and proceed to a scrubber 2 before release into the atmosphere or recycling. Combustion and effluent gases also exit the housing through apertures 28 or 29 and proceed to the scrubber 2 via an auxiliary scrubber 1. Before these gases are released into the atmosphere they are recycled through the scrubbers and/or passed through a thermal oxidiser and optionally a catalytic converter (not shown) so as further to reduce the emission of noxious gases such as sulphur dioxide and oxides of nitrogen.

An alternative embodiment of the present invention is shown in the broken outline of Fig.2. Here the irradiation and combustion steps do not take place in the same chamber. The residue obtained by irradiation of the carbonaceous material are removed from the chamber 12 to a second chamber 31 (indicated by broken lines) where combustion is conducted. The transfer of the residue from the irradiation chamber 12 to the combustion chamber 31 may be mechanical, for example by use of a belt or roller conveyor or slat conveyor. The chambers may be located in the same housing 11 although it will be understood that the scope of the invention includes the possibility that the combustion chamber may have its own housing 30 (as shown).

Referring now to fig. 3 a further embodiment of the present invention includes a housing 11 having a weighing chamber 32, an irradiation and combustion chamber 12 and an ash collecting chamber 33. The features of the chamber 12 are similar to those previously described except that there is now provided no opening 14 in the front wall for introduction of the coffin and body. Instead weighing chamber 32 is provided with the opening means for introducing the coffin and body 13 into the housing 11. Weighing chamber 32, irradiation and combustion chamber 12 and ash collecting chamber 33 are connected by a lowering partition screen 34 and transfer means that allows lateral transfer of the coffin and body from one chamber to the next. In this embodiment the control dials 20 for controlling the mechanical, electrical or computing machinery are located at the back of the compartment 19 of chamber 11. Ash collecting chamber 33 is shown with partition screen 34 lowered so as to allow collection of ash. The chamber also comprises a cavity such as that

provided by a drawer (not shown). The cavity or drawer may contain or be otherwise connected to a cremulator (not shown).

Referring now to Fig. 4, there is shown an embodiment of the invention in which two separate housings 11 for single chamber irradiation and combustion are stacked one above the other. The housings 11 are secured by connection means (not shown) and orientated with the openings 14 and doors facing in opposite directions from each other. The dimensions of the housing 11 are typically such that they may be arranged between walls or floors in a building. This embodiment may therefore allow the simultaneous treatment of more than one coffin and body whilst maintaining the separate identity of the treatment products and any gatherings of mourners that may be present. Furthermore such an embodiment allows the economic use of plant such as the machinery for generating nitrogen gas etc.

In another embodiment of the present invention (not shown), in which housings 11 are stacked so as to face the same direction, ash collecting means are not arranged according to removable drawers. Instead each housing 11 is adapted so as to provide a separate chute at or near the back wall of the housing so as to each connect to a dedicated cremulator located at a position on or below the ground. The number of housings that may be stacked upon or adjacent each other is not therefore limited by the need to provide space for removal of drawers or the like.

The housing of the present invention may come in a variety of sizes according to available space or stacking considerations. The materials used for the construction of the housing including microwave protection screens may be any known to the art including GRP and stainless steel. The number of microwave generating transducers 24 in the housing may vary according to the nature of the material to be processed.

A typical process for the treatment of a coffin containing a body according to the embodiment of Fig. 1 of the present invention involves the following steps. The coffin 13 is weighed prior to its introduction into a housing 11. The operator enters the details via the key pad 25 and selects a programme for the treatment process. The chamber 12 is evacuated and then purged by the introduction of nitrogen or oxygen-depleted air. Purging of the chamber 12 is continued whilst microwave irradiation of the coffin 13 is commenced. The effluent gases of the irradiation process (mostly carbon dioxide and water in the form of steam) are carried away by the purging gas. Irradiation is continued according to a calculated time or until the operator, observing through the spy holes 26 intervenes.. At the end of the irradiation process a combustible gas and air or oxygen are introduced into the chamber 12 and ignited by operation of ignition means 21 provided in the floor 16 of the chamber. The effluent gases of the combustion process are carried away by the purging gas. The combustion continues according to the pre-selected programme or until such time as is determined by the operator observing through the spy holes 26. After combustion is terminated, the ash is allowed to cool under continued purging of the chamber 12 with nitrogen or oxygen-depleted air. After

cooling, the ash is collected by withdrawal of the chamber floor 16 and transferred to a cremulator for final comminution before collection.

The present invention provides a portable housing for use with an apparatus for the safe treatment of human remains. Having described embodiments of the invention with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected by one skilled in the art without departing from the scope of the invention as defined in the appended claims.

For example depletion of oxygen from chamber 12 may be accomplished by evacuation under reduced pressure before introduction of the nitrogen or oxygen-depleted air. The gangway 15 of chamber floor 16 may have an associated charcoal bed to provide for combustion after irradiation. The coffin may be introduced into the housing by withdrawal and retraction of the chamber floor via the side of the housing. Other modifications to the process and apparatus of the present invention may include recycling the nitrogen gas or oxygen-depleted air and providing a roller conveyor for introducing the coffin 13 into the housing 11 and chamber 12.

CLAIMS

1. A process for the treatment of carbonaceous material comprising the steps of

i) introducing the material, into a chamber having closure means,

ii) extracting or displacing oxygen from the chamber so as to provide a substantially oxygen-depleted atmosphere,

iii) effecting a preliminary treatment of the material by irradiating with electromagnetic radiation of sufficient power and for a sufficient period to cause substantial degradation of the carbonaceous material to an ash-like residue, and

iv) raising the temperature of the thus-obtained residue in the presence of oxygen or air whereby to cause combustion and reduce the said residue to an ash.

2. A process according to claim 1, in which step iv) is performed by combustion of at least one combustible gas.

3. A process according to claim 2, in which step iv) comprises introducing oxygen or air and the said at least one combustible gas into the said chamber.

4. A process according to claim 2, in which step iv) is performed by removing the residue resulting from step ii) from the said chamber to a second chamber, equipped with means for introducing oxygen or air and the said at least one combustible gas.

5. A process according to any of claims 2 to 4, in which ignition of the said at least one combustible gas is initiated by further irradiation with electromagnetic radiation.

6. A process according to any preceding claim, in which step ii) is performed by introducing an inert gas or oxygen-depleted air into the said at least one chamber whereby substantially to fill the said at least one chamber.

7. A process according to claim 6, in which the said inert gas is nitrogen.

8. A process according to any preceding claim, in which step iii) is performed by irradiating the material with microwave radiation.

9. A process according to any preceding claim, including the step of weighing the carbonaceous material to determine the energy level and/or time for irradiation.

10. A process for the treatment of human or animal remains, comprising the process of any one of claims 1 to 9.

11. A process according to any preceding claim, including the further step of cooling the solid products of step iv).

12. A process according to any preceding claim, including the further step of collecting the solid products of step iv).

13. A process according to any preceding claim, including the further step of pre-heating the said material before step iii).

14. A process according to any preceding claim, in which the gaseous products of steps iii) and/or iv) are trapped by chemical reaction or physical transformation.

15. Apparatus for the treatment of carbonaceous material comprising a housing defining at least one chamber and having an opening for introducing the material into the said at least one chamber together with closure means for closing the said at least one chamber, the housing also comprising means for extracting or displacing oxygen from the said at least one chamber so as to provide a substantially oxygen-depleted atmosphere in the said at least one chamber, means for irradiating the material in the said at least one chamber with electromagnetic radiation of sufficient power and for a sufficient time so as to cause degradation of the said material to a residue, means for admitting oxygen or air into the presence of said residue, and means for raising the temperature of the said residue within the said at least one chamber so as to cause substantial combustion thereof to lead to an ash.

16. Apparatus according to claim 15, further comprising means for introducing at least one combustible gas into the presence of the said residue and means for ignition of said at least one combustible gas.

17. Apparatus according to claim 16, in which said means for ignition of said at least one combustible gas comprises irradiation with electromagnetic radiation.

18. Apparatus according to any of claims 15 to 17, further comprising means for weighing the carbonaceous material prior to, or upon introduction of the said material into the said at least one chamber.

19. Apparatus according to any of claims 15 to 18, further comprising means for cooling the solid products of the said combustion.

20. Apparatus according to any of claims 15 to 19, further comprising means for collection of the said products of combustion.

21. Apparatus according to any of claims 15 to 20, further comprising means for pre-heating the said carbonaceous material.

22. Apparatus according to any of claims 15 to 21, in which the said means for extracting or displacing oxygen from said at least one chamber comprise means for introducing a substantially inert gas or oxygen-depleted air whereby to substantially fill the said at least one chamber.

23. Apparatus according to claim 22, in which said inert gas is nitrogen

24. Apparatus according to any of claims 15 to 23, further comprising means for trapping the gaseous products of said combustion.

25. Apparatus according to any of claims 15 to 24, in which the said at least one chamber is formed in a portable housing, said housing having means for connection to an external energy source.

26. Apparatus substantially as hereinbefore described, with reference to, and as shown in the accompanying drawings.

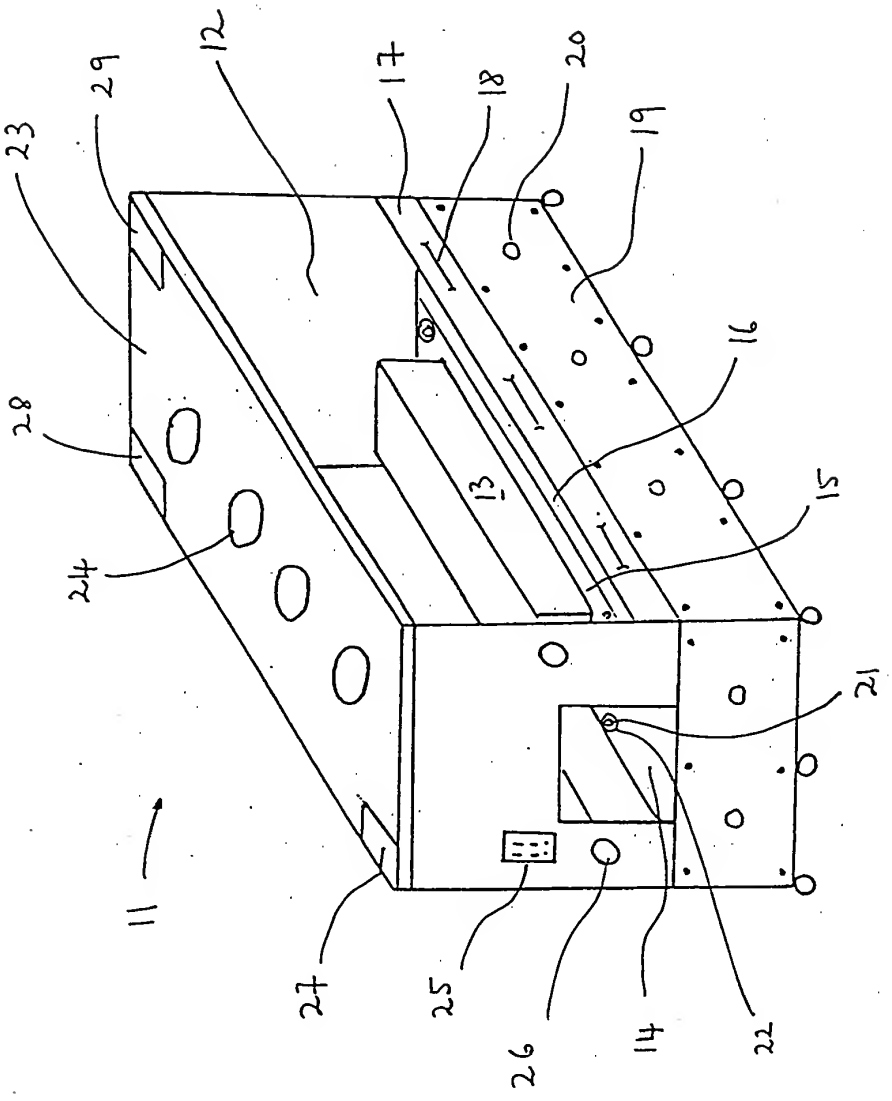

Fig. 1

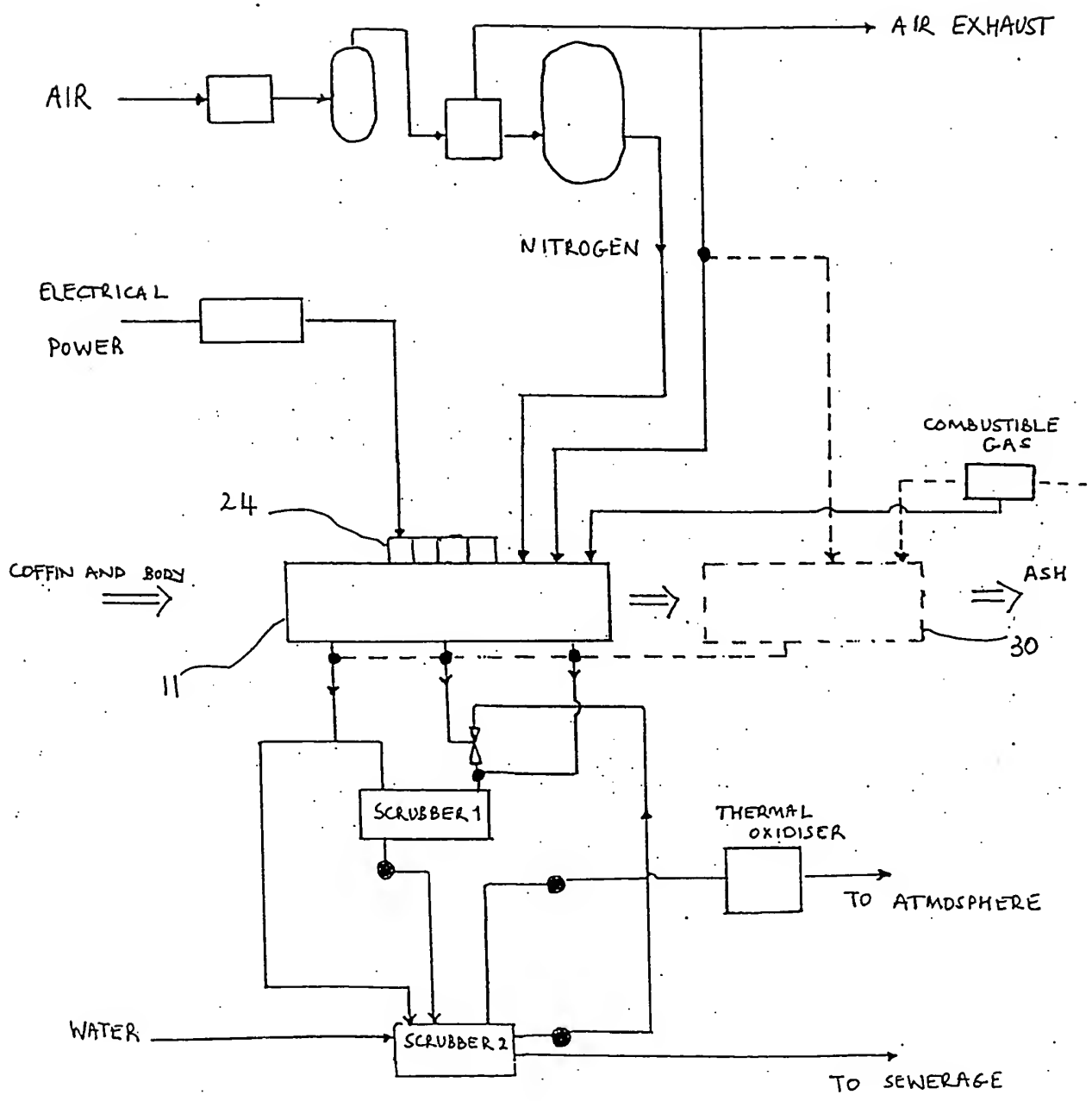
AIR EXHAUST
AIR
NITROGEN
ELECTRICAL
POWER
COMBUSTIBLE
GAS
24
COFFIN AND BODY
ASH
30
11
SCRUBBER 1
THERMAL
OXIDISER
TO ATMOSPHERE
WATER
SCRUBBER 2
TO SEWERAGE

Fig. 2

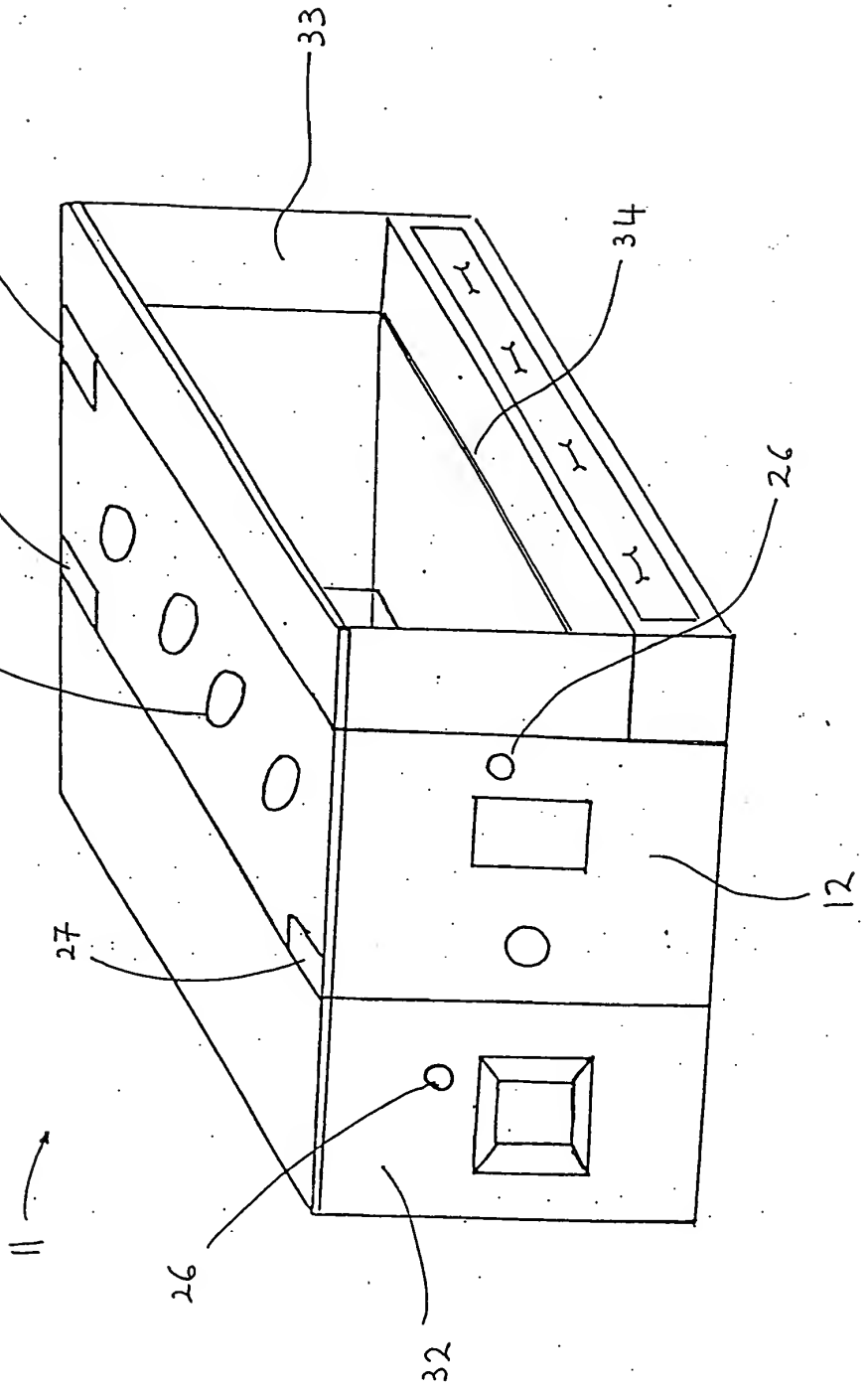

Fig. 3

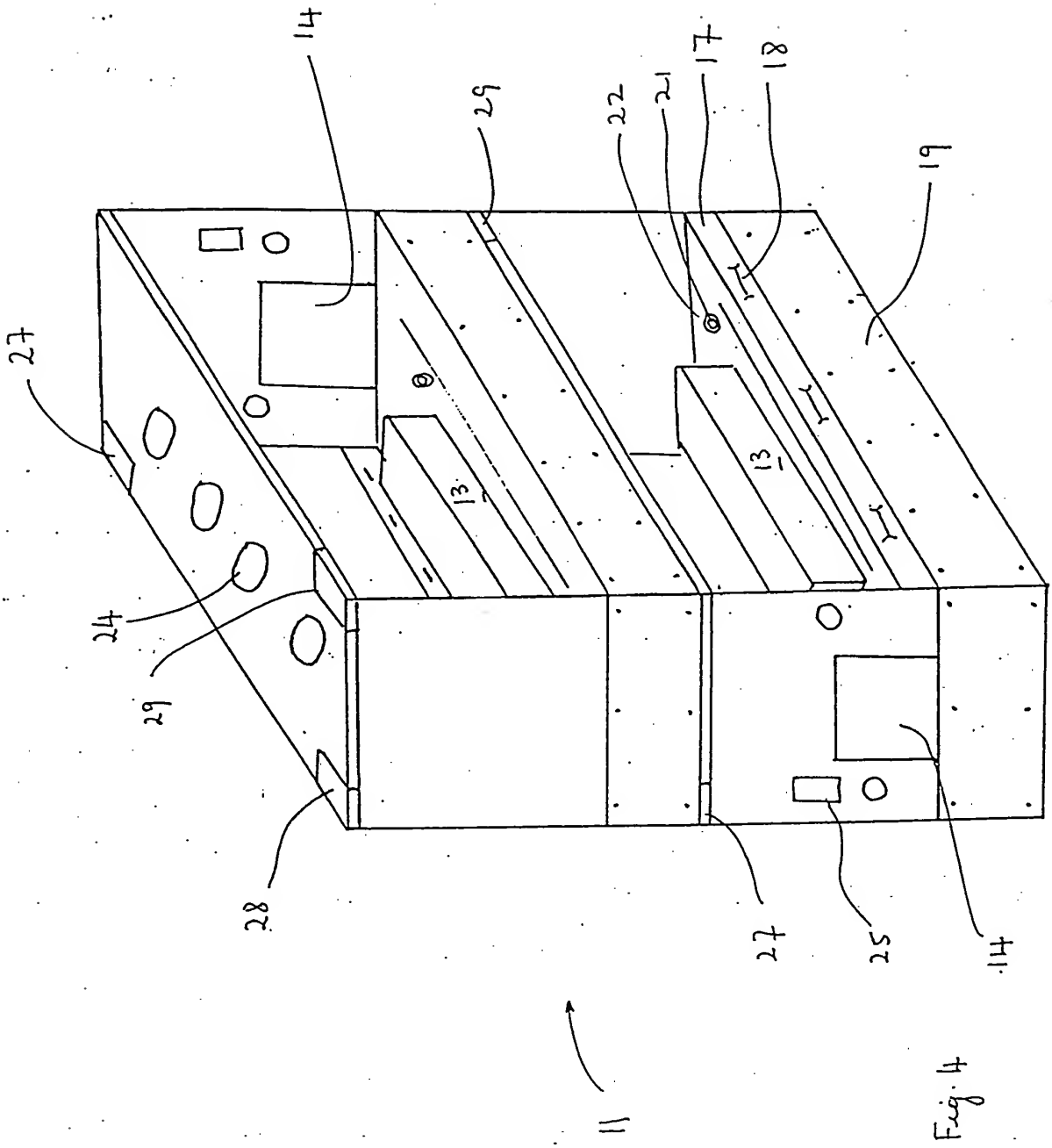

Fig. 4

PCT/GB00/03546

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